

Local Human Capital Externalities or Sorting? Evidence From a Displaced Workers Sample

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Abstract

In this paper we want to assess if the positive association between individual earnings and local average education is due to human capital externalities or just reflects some omitted factors. Using a sample of displaced workers, we take into account firm characteristics as well as individual fixed effects. We find that, on average educational externalities are quite small, however it seems that these externalities are not captured equally by different types of individuals. More educated workers benefit from a highly-educated environment relative to workers with lower levels of education (about 3% more) and these gains are not all acquired immediately, but through time.

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Key Words: Human Capital Externalities, Education, Wages, Agglomeration.

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1 Introduction

Human capital externalities, and particularly educational externalities, play a prominent role in many recent endogenous growth models, but also in the literature on city formation, neighborhood effects and, more generally, in discussions of income inequality. The economic rationalization of the government subsidies to private education is based on the belief that there are important external effects from increased schooling attainment. However the obvious question that has not been empirically clearly answered, is whether the private return differs from the social return to education (Card, 1999). In fact, the literature available is almost entirely on the private rather than social returns to education, and only very few studies try to design an analytic approach that credibly generates a consistent estimate of the causal effect of interest.

Although, there is no doubt that there exists a positive correlation between local average education and individual wages, even after controlling for individual observable characteristics, such as experience, gender and education. As an example, a difference of one year on average schooling in the Portuguese counties, is associated with an individual wage gap of 8.4%, similar to the one found for the U.S. case¹. However, this association does not imply the idea that the relationship represents a causal effect or just reflects that more able workers choose to work in better-educated cities, for example. Changes in average local education levels may also raise wages less than the private returns to schooling if education is a complement of some inelastically supplied factor of production, or if schooling has a signaling value. Nevertheless, most of the theoretical literature

¹Acemoglu and Angrist's (2001) OLS results, using data from 1950 to 1990, leads to an estimate of 7.2%, controlling for state of residence main effects, and between 12.8% and 16.8% without state of residence controls.

on this issue lays on the assumption that the social value of education exceed the private return, through human capital externalities from a more educated labor force².

New growth theory often states that externalities that arise from education are one of the key elements of the economic growth and on the spatial agglomeration of production. According to Lucas (1988), human capital externalities in cities are viewed as a key determinant of the development of nations. Other economists have also recognize that social returns to education may differ from the private ones. As an example, Marshall (1890) argued that social interactions among workers of the same industry enhance their productivity.

The role of the firm might also be considered. Externalities from education may arise if human and physical capital are complementary factors of production, and if firms choose their physical capital in anticipation of the average human capital of the workers they will employ in the future³. In this case, firms that use more intensively physical capital will be attracted to cities where labor force is more educated. Therefore, if matching is random and breaking the match is costly, equilibrium wages will increase with the average education of the workforce. Some workers who have not increased their education will work with more physical capital and earn more than the same type of workers in locations with lower human capital levels. On the other hand, is possible that workers learn from each other in their place of work. Hence, workers in firms with higher average level of education will earn more not only because they work with more physical capital, but also because they become more productive, through interactions with other co-workers.

²e.g. Rauch (1993).

³For a formal model, see Acemoglu (1996).

However, despite the substantial theoretical literature and the importance of this issue for economic policy, much less is known about the empirical relevance of the social returns to education than the private returns. One possible explanation for this, is the difficulty of the study of market-level externalities relative to the study of individual-level private returns. In fact, the problem of identification related to the estimation of social returns is more accurate, than the one that arise from the estimation of the private returns. The possible endogeneity of both regressors, individual education and average education⁴, implies that the observed association between schooling variables and wages is not necessarily causal. In fact, with worker mobility, and if there is a local public benefit from private knowledge, there is also an incentive for sorting of higher ability workers, leading to regional variations of individual wages, even if observable characteristics of the workers are controlled for. Therefore, the positive association between individual wages and local average education possibly not only include the education externalities but also reflects that more able workers choose to live in more educated cities. If the association between local average education and individual wages is only due to sorting of high ability workers, than the social return to education estimated by a fixed effects model should be zero, considering that individual ability is time invariant.

Another identification problem is related with the possibility that workers with different levels of education are imperfect substitutes in production (e.g. Autor, Katz and Krueger (1998), Card and Lemieux (2000)). Increasing the aggregate supply of highly educated workers will increase wages of workers with low levels of education and decrease wages of workers with high levels of edu-

⁴In Rauch (1993), average education is treated as exogenous.

cation, even if wages reflect their marginal social products. A recent paper of Ciccone and Peri (2002) proposes an approach to the identification of human capital externalities at the aggregate level whether workers with different human capital are imperfect substitutes in production. Nevertheless, under the capital-skill complementarity hypothesis, the problems of estimation of the externality under imperfect substitution are not so severe, because unskilled labor is more substitutable by physical capital than skilled labor.

Despite of the absence of experimental evidence, some of the few available studies of market-level education externalities used some ideas that underlie the quasi-experimental studies of the private return to education. As an example, Acemoglu and Angrist (2001), use instruments for average schooling derived from compulsory attendance laws and child labor laws in states of birth. They found a small social return to education (less than 1%, not significantly different from zero), which is also consistent with the Ciccone and Peri’s results. In contrast, Moretti (2002) instruments for average schooling with the lagged city demographic structure and the presence of land-grant college, and found that an increase of 1% share of college graduates raises individual wages in the range between 1.9% and 0.4%, according to different individual education status⁵.

In this paper we want to assess how strong are the externalities that arise from education, using longitudinal individual data for the years 1989 to 1999. This data provides information about both employers and workers by location. The data is taken from the “Quadros de Pessoal” of the Portuguese Ministry of Labor and Solidarity, which collects information on all companies operat-

⁵The difference between instruments can be one explanation for different results found by these studies. While Moretti’s instruments induce more variation in College attendance, the instruments used by Acemoglu and Angrist affect mainly high school drop-outs.

ing in Portugal. With this dataset, it is possible not only to control for the observable characteristics of the firm, namely the effect of the general level of education within the firm on the individual's productivity, but also to take into account individual fixed effects, in order to control for time invariant individual characteristics. At this stage we will use panel data about exogenously displaced workers, who lost their jobs because of firms closings. This information is needed not only because we get more variation on the variables of interest, since displaced workers are more likely to move, but also because this geographical mobility after displacement is more likely to be exogenous. We then test the hypothesis that education externalities probably do not benefit all workers equally, but accordingly to their education level. This information about displaced workers will also be used to check if the human capital externalities are captured immediately, or only over time, in other words, whether movers to locations with higher average education levels enjoy faster wage growth than those who stay.

Our empirical results, controlling first for city fixed effects, do not indicate a significative social return to education. These results are even stronger if firm characteristics are accounted for. This small effect is consistent with the more recent empirical works on this subject. Nevertheless, it seems that the ability to capture this externality differs depending on the type of worker. Using a sample of displaced workers, after 5 years of being displaced, the wages of a college graduate increase by more than 3%, relative to a worker with basic education if both observe a change in the average education of their county by one year. This result is robust to the inclusion of some mobility controls, and do not differ between sub-samples of movers and stayers. On the other hand, there is some

evidence that returns to tenure tend to increase with average city education, which is a sign that this kind of externalities are not acquired immediately, but along time.

The structure of the paper is as follows. Section 2 presents a series of possible explanations for the influence of local human capital on wages, and sets out the main features that will be examined in the empirical work. Section 3 describes the data and the estimation strategy, Section 4 presents the results and, finally, Section 5 concludes.

2 Human Capital Externalities: Theoretical and Measurement Framework

2.1 A simple model

Consider a city c that produces a single commodity Y_c , the price of which is normalized to one. This output is produced in a competitive economy and traded on the national market. There are L_c workers in the city, and the single production input is labor. The aggregate production function for each city takes the following form:

$$Y_c = A_c \left[\sum_{i=1}^{L_c} h_i \right], \quad (1)$$

where h_i is the worker's i human capital. Therefore, the output per worker is:

$$y_{ic} = A_c h_i, \quad (2)$$

which is equal to his gross earnings, $w_{ic} = A_c h_i$.

A_c is the productivity shifter, and we allow to depend on a measure of aggregate human capital H_c . The motivation for this modelization is based on the Lucas's (1988) argument that human capital has important external returns. These externalities arise through the exchange of ideas, imitation, or learning by doing. We will refer to these external effects as technological or interaction externalities, because these effects work not through prices, but directly through the production function. As in Lucas (1988), the measure of aggregate human capital is the average human capital in the city, $H_c = E[h_i] = \bar{h}_c$, and hence:

$$A_c = D_c \bar{h}_c^\theta. \quad (3)$$

In this set up, human capital externalities are captured by the elasticity θ and D_c measures a city fixed effect. Therefore, individual earnings are:

$$w_{ic} = A_c h_i = D_c \bar{h}_c^\theta h_i, \quad (4)$$

and taking logs, we have:

$$\log w_{ic} = \log D_c + \theta \log \bar{h}_c + \log h_i. \quad (5)$$

With this formulation, in order to estimate θ we need data on individual human capital, wages and on some measure of \bar{h}_c , for each city.

2.2 Considering individual heterogeneity on human capital supply

A more realistic model would have to assume some heterogeneity in individual characteristics. We now consider that individuals are heterogeneous in terms of their unobserved ability $\eta_i = \alpha_i \eta(s_i)$, which depends on an individual characteristic α_i , and also, potentially, on schooling. Suppose that their human capital can be expressed as a function of their individual schooling and ability: $h_i = \exp(\beta_\eta \eta_i + \beta_s s_i)$, where β_η and β_s are the returns to ability and education, respectively.

Consider that the cost function of acquiring s_i of education is $\frac{1}{2}q_i s_i^2$, where q_i is the cost of education, or, as in Card (1995), the personal discount rate for individual i .

The optimal level of individual schooling is chosen by each individual by maximizing the following function:

$$U(C_{ic}, s_i) = \log C_{ic} - \frac{1}{2}q_i s_i^2, \quad (6)$$

where C_{ic} is the worker's i consumption in city c .

Assume, also, that workers supply their human capital inelastically, and having acquired it instantaneously at the beginning of their single-period life. They borrow the requisite funds to support the cost of education at a zero interest rate, and there are no savings. Therefore, $C_{ic} = w_{ic}$, and $\log C_{ic} = \log w_{ic} = \log D_c + \theta \log \bar{h}_c + \beta_\eta \eta_i + \beta_s s_i$. The equilibrium schooling s^* levels satisfies:

$$\beta_\eta \alpha_i \eta'(s_i^*) + \beta_s = q_i s_i^*. \quad (7)$$

As long as η_i or q_i differs across workers, the optimal schooling levels will also potentially be different. For example, suppose that $\eta'(s_i) > 0$, and $\eta''(s_i) < 0$, which means that individual ability increases with education at a decreasing rate. Individuals with more α_i or facing lower q_i , tend to get more schooling.

City average human capital can be approximated to average schooling, assuming that $\log \bar{h}_c = \log E_c[h_i] \approx c_0 + c_1 E_c[\log h_i]$ and $c_0 + c_1 E_c[\log h_i] = c_0 + c_1 E_c[\beta_\eta \eta_i + \beta_s s_i] = c_0 + c_1 \beta_\eta E_c[\eta_i] + c_1 \beta_s E_c[s_i]$. With $\theta c_1 \beta_\eta E_c[\eta(s_i)] = \gamma_{\bar{\eta}} \bar{\eta}_c$, defined as the city average ability, $\gamma_{\bar{\eta}}$ the external return to average ability, and $\theta c_1 \beta_s = \gamma_{\bar{s}}$, estimation of the schooling externalities can be based on the following equation:

$$\log w_{ic} = \gamma_0 + \log D_c + \gamma_{\bar{\eta}} \bar{\eta}_c + \gamma_{\bar{s}} \bar{S}_c + \beta_\eta \eta_i + \beta_s s_i + u_{ic}, \quad (8)$$

where $\bar{S}_c = E_c[s_i]$ is the average schooling in city c , and u_{ic} is the individual error term. The main problem to estimate the parameter of interest $\gamma_{\bar{s}}$, is the possibility of correlation between either $\bar{\eta}_c$ and \bar{S}_c , or η_i and \bar{S}_c or s_i , because average and individual ability are not directly observed. This correlation arises from the endogenous schooling decision process. However if individual schooling and individual ability are both time invariant, a model with individual fixed effects could solve the endogeneity problem caused by these regressors. But, we still have the problem on the OLS estimation if there is any correlation between changes on average ability and changes on average education, even if we take into account city fixed effects. One possible source of this correlation arises if

the benefits of the interaction process is not only linked with the education of the workforce but also on its average skills, which means that γ_η is not zero. If this correlation is positive, then OLS overestimates the true externality $\gamma_{\overline{S}}$, and the estimated result includes the externality that arises from the interaction with other components of the average human capital.

The other possible source of endogeneity, related with the possible correlation between average ability and average education, concerns the worker's location decisions. If more able workers choose cities with more educated labor force, then the association between average education and individual wages is not necessarily causal. On the other hand, we have to insure an equilibrium in which workers must be indifferent between living in different cities.

2.3 Considering city heterogeneity on human capital supply and demand

Consider now the local public goods model of Roback (1982). This model assumes that households and firms are freely mobile between cities (no transportation costs), and there are no inter-city commuting. In equilibrium, the relevant utility acquired by workers must be identical across cities $U_{ic}(w_{ci}(H_c), z_c, r_c) = U_{ik}(w_{ki}(H_k), z_k, r_k)$, where c and k denote city, $w_{.i}$ denote wages, $r_{.i}$ rents and $z_{.i}$ are vectors of all characteristics of cities that are relevant for utility U , such as degree of pollution or quality of the public goods.

Firms combine capital, local labor and local land to produce the tradable single commodity. The price of capital is set in international capital markets and therefore is equal across locations as the price of the commodity, as before. Production technology is C.R.S. in all production inputs, and loca-

tion characteristics enter in production as Hicks-neutral shift parameters (as the parameter D_c in the above framework). Spatial equilibrium then requires $c(w_c(H_c), z_c, r_c) = c(w_k(H_k), z_{ck}, r_k) = 1$, where c is the unit cost of production, normalized to one, for simplicity.

Suppose an increase in z (a shock in local conditions) in city c that increases individual utility mainly for more skilled workers and also their own productivity. Then, as more skilled workers are attracted to the city, rents will increase, because land is supplied inelastically, and lower skilled workers would move to other city. Therefore we will observe positive correlation between average wages and average education, even without human capital externalities. This fact implies that some local demand variables must be added in order to control for these shocks.

Note that in this set-up, the differences in living standards are not relevant for individual wage determination. Firms producing traded goods face the same prices and have to receive the same rate of return to physical capital, and therefore they must have a more productive workforce in high wage cities. Only firms producing nontraded goods may care about local prices.

2.4 Considering firm heterogeneity

So far, all the works on this subject do not consider firm heterogeneity, but we also should take into account the hypothesis of sorting of heterogeneous firms across space. For example, firms differ in terms of their wage policies, for example, rewarding differently the human capital of their workers. It is hard to believe on the assumption that the labor market is perfectly competitive. Therefore, we should accept that exists different mechanisms of wage bargaining,

across sectors or firms. Hence, if there are sectors in which workers are more capable to gain a larger share of the economic rents, then these sectors will show a positive wage premium not related with productivity. In our framework, if these kind of sectors (e.g. banking or transports) are located mainly in high educated cities, than differences in wages across space are not only due to human capital externalities, but also are associated with spatial sorting of sectors with different wage policies. Even within sectors it is also plausible that firm's wage policies can differ between them. If more educated workers are possibly more able to bargain and to capture a large share of the economic rents, then the average human capital of the firm should be also correlated with the individual's wage. Also, it is natural that part of the interaction spillovers are not captured outside the firm, but within firm. As workers with different skills interact during the production process, they exchange relevant information between themselves, and therefore a significant part of the city externalities are in fact firm specific, and cannot be considered as externalities.

Hence, in our model, we could consider that A_c , the productivity shifter, depends also on the firm's characteristics Z_j :

$$A_{cj} = D_c Z_j^\delta \bar{h}_c^\theta. \quad (9)$$

With this formulation, it is easy to see that we have to add the term $\delta \log Z_j$ to our wage equation.

Note that controlling for firm characteristics also allow us to focus on interaction (technological) externalities, rather than pecuniary externalities, as in the Acemoglu's (1996) model. Even if firms choose more capital in locations with more human capital, we expect to capture this with our control variables.

2.5 Considering imperfect input substitution

So far, we have been considering that workers with different levels of human capital are perfect substitutes. However, with imperfect substitution, the productivity of low skilled workers will increase, as the share of high skilled increases, even in the absence of any externality (see, for example Ciccone and Peri, 2002). On the other hand, the impact of the increase in the share of better educated workers on their own wage is determined by two competing forces: the first is the conventional effect which makes the economy move along a downward sloping demand curve, while the second is the externality that raises productivity. To illustrate this, let's consider now a variation of the first model, where we include two types of labor. The product Y_c of the city c is produced under a CES production function that combines two types of labor: skilled H_c and unskilled L_c :

$$Y_c = A_c [L_c^\rho + H_c^\rho]^{1/\rho}, \quad (10)$$

where $\rho < 1$ if L and H are imperfect substitutes, or $\rho = 1$ if L and H are perfect substitutes. The elasticity of substitution between labor and human capital is given by $\sigma = 1/(1 - \rho)$.

Assuming that A_c is a productivity shifter, and, as before, we let to depend on the average level of human capital $\bar{h}_c = H/L$, and on a constant exogenous city specific factor D_c :

$$A_c = D_c \bar{h}_c^\theta, \quad (11)$$

Assuming that the price of labor w^L and the price of human capital w^H are

equal to their marginal products, and firms take A_c as given, we have:

$$w_c^L = \frac{\partial Y_c}{\partial L_c} = A_c \left[1 + \bar{h}_c^\rho \right]^{\left(\frac{1-\rho}{\rho}\right)}, \quad (12)$$

and

$$w_c^H = \frac{\partial Y_c}{\partial H_c} = A_c \left[\bar{h}_c^{-\rho} + 1 \right]^{\left(\frac{1-\rho}{\rho}\right)}. \quad (13)$$

Now we can analyze the elasticity of the average human capital \bar{h}_c on the above prices:

$$\epsilon_L = \frac{\partial \ln w_c^L}{\partial \ln \bar{h}_c} = (1 - \rho)\Pi_H + \theta, \quad (14)$$

where $\Pi_H = \frac{h^{(\theta_H+1)\rho}}{h^{\theta_H\rho} + h^{(\theta_H+1)\rho}}$ is the share of human capital in total labor costs.

This expression shows that the elasticity ϵ_L of the average human capital on the price of labor is always positive (assuming non-negative externalities and $\rho < 1$). Even with $\theta = 0$, the elasticity is positive under imperfect substitution between labor and human capital: an increase in human capital implies an increase in the marginal productivity of the raw labor, increasing its price. Only with perfect substitution ($\rho = 1$), ϵ_L is equal to the externality θ .

Consider, now the elasticity of the average human capital h on the price of human capital:

$$\epsilon_H = \frac{\partial \ln w^H}{\partial \ln h} = -(1 - \rho)(1 - \Pi_H) + \theta.$$

This means that the net effect of an increase in average human capital in the price of human capital will be positive only if the strength of the externality θ is larger than the negative effect $-(1 - \rho)(1 - \Pi_H)$, the conventional supply effect which makes the economy move along a downward sloping demand curve.

If imperfect substitution of different worker types is relevant, then we only can infer the existence of an externality if the increase in average education is related with an increase of the wage of the better educated workers. Therefore, we have to compare the size of the coefficient associated with average education across different education groups in order to shed some light on the size of the spillover.

2.5.1 A possible extension: considering the capital-skill complementarity hypothesis

The above framework shows the standard results found in the literature concerning the identification of human capital externalities at the city level. However, these literature (e.g. Ciccone and Peri, 2002; Acemoglu and Angrist, 2001; Moretti, 2002), consider that the elasticity of substitution between capital and unskilled labor is the same as the one between capital and skilled labor or human capital. This is a strong assumption since the estimates of substitution elasticities between capital and skilled labor are consistent with capital-skill complementarity hypothesis, which means that the elasticity of substitution between capital and unskilled labor is higher than between capital and skilled labor (see Krusell, Ohanian, Ríos-Rull, and Violante, 2000).

This hypothesis of capital-skill complementarity is formalized by Griliches (1969), and we can illustrate this in our framework with a very simple model. Consider that output in city c is produced with capital K_c , human capital H_c and raw (unskilled) labor L_c , as before. Capital and raw labor are perfect substitutes and have unit elasticity of substitution with human capital:

$$Y_c = (A_c H_c)^\alpha (A_c L + K)^{1-\alpha}. \quad (15)$$

The marginal productivity of capital is equal to its price p_K and is:

$$p_K = \frac{\partial Y}{\partial K} = (1 - \alpha) \left(\frac{A_c H}{A_c L + K} \right)^\alpha. \quad (16)$$

If the price of capital is the same in all country, and normalized to $(1 - \alpha)$, therefore:

$$p_K = (1 - \alpha) \Leftrightarrow \left(\frac{A_c H}{A_c L + K} \right)^\alpha = 1 \Leftrightarrow \quad (17)$$

$$K = A_c H - A_c L, \text{ with } \alpha \neq 0. \quad (18)$$

Therefore, the prices of labor and human capital are (and considering A_c defined as before):

$$w^L = \frac{\partial Y}{\partial L} = (1 - \alpha) A_c, \text{ and} \quad (19)$$

$$w^H = \frac{\partial Y}{\partial H} = \alpha A_c.$$

The price of labor is identical to the price of capital times the productivity shifter A_c . It is straightforward to calculate the elasticities ϵ_L and ϵ_H :

$$\epsilon_L = \frac{\partial \ln w^L}{\partial \ln h} = \theta, \text{ and} \quad (20)$$

$$\epsilon_H = \frac{\partial \ln w^H}{\partial \ln h} = \theta. \quad (21)$$

This is an interesting result: even with imperfect substitution between L and H we can obtain elasticities ϵ_L and ϵ_H similar to the ones under perfect substitution, if labor is perfectly substitutable by capital. Therefore, and assuming the capital-skill complementarity hypothesis, we can assume a range of variation for ϵ_L and for ϵ_H :

$$\theta < \epsilon_L < (1 - \rho)\Pi_H + \theta \quad (22)$$

and

$$-(1 - \rho)(1 - \Pi_H) + \theta < \epsilon_H < \theta. \quad (23)$$

This result means that an estimate of ϵ_L may overstates the true value of θ , while an estimate of ϵ_H can be thought as a lower bound of the true value θ .

3 Econometric Framework

3.1 General Discussion

As we quoted before, the main identification problem of the education externalities, in an equation like (8) is the omitted-variables bias that arise from the correlation between average schooling and individual or average ability, and other city-year effects embodied in the error component. Individual ability can be controlled in a first differences estimation strategy, using individual data, but we still have a problem of identification if individual ability is remunerated

differently across locations or across time, which means that the parameter β_η in equation (8) might be written as $\beta_{\eta ct}$. However, we try to mitigate this bias using a displaced workers sample, in order to reduce this bias, because the choice of the location to work after displacement is more likely to be exogenous than the one in the sample of all population. Also, once we control for some firm characteristics we are ruling out differences in the ability premium that are firm specific, and (potentially) change over time. A similar problem holds if variations in city average ability are correlated with changes in average education, and if average ability has some role in the individual wage setting. In this case our estimate of the educational externality we will be biased up.

Another source of bias is the measurement error in individual education. If grouping (averaging across all individuals within a city) corrects for attenuation bias due to measurement error in s_i , that the coefficient associated with average education will be biased up (see Acemoglu and Angrist, 2001, for a formal proof). The opposite holds if grouping eliminates correlation between s_i and unobserved ability. Also, we have to take into account the measurement error bias induced by the measurement of the variable average education due to the fact that we are only observing full time workers in the private sector of the economy. Note that we can not identify employees on the public administration, as well as unemployed workers. Suppose, for example, that the average education of employees in Public Administration is higher than the average education of the workers in private sector, and the share of public jobs, is higher in cities with low educational standards. Therefore our estimate of the coefficient associated with the local average education will be biased up (or down if the opposite is true).

The other source of omitted-variables bias is related with local demand or supply shocks in the labor market. Suppose that economic growth is faster in cities with higher average education, then we will observe an increase in wages in those cities not related not motivated by education externalities. Having this in mind, we try to control for these local shocks by including two additional variables (in addition to the city dummy): the (log of) city employment and the (log of) per capita value of the city gross production (which the summation of the sales of all firms located in the city, divided by the number of workers). A positive shock on the local demand conditions will cause an increase in the city labor force, or, alternatively, an increase in the per capita gross product, if the labor supply does not react to this shock.

The usual way to deal with this identification problem is to follow an IV strategy. However, a good instrument that provides an exogenous variation in the average education on *all distribution* of skills is required. So far, the instruments used are basically two: changes in compulsory schooling laws (Acemoglu and Angrist, 2001) and city demographic structure (Moretti, 2002⁶, and Ciccone and Peri, 2002). The first instrument affects mainly educational attainment in the lower part of the distribution, mostly in middle or high school dropouts, while the variations motivated by the second instrument are related with the presence of young cohorts of workers in the city labor force. Only by chance we can expect that the external effect induced by one year average education increase in a city, motivated mainly by those who finish high school or by young

⁶Moretti (2002) also used the presence of a land-grant college as an instrumental variable. However this instrument cannot be used in a specification that includes city fixed effects, because it would be absorbed by the fixed effect. In our case, as we show next, the consideration of city fixed effects is crucial in this set-up, because these effects explain the major part of the association between average education and individual wages.

highly educated workers, has the same impact on individual productivity as a similar increase obtained by a rise in college graduates with some labor experience. The other way to induce exogenous variation in the worker's educational environment is not to look for changes in the environment itself, but consider quasi-exogenous mobility of the workers, and that is what we intend to do in the second part of the estimation strategy.

3.2 Estimation Strategy

Our estimation strategy will be the following: first we will estimate versions of the basic mincerian wage equation on all workers' sample (pooled cross-sections from different years), adding information about the relevant characteristics of the worker's location. The second step will be to regress the wage equations but now on the displaced workers' sample. Estimating the equations in first differences, we can control for individual fixed effects. The use of the displaced workers sample provides much more variation in the independent variable *average county education* as well as in the *average firm education* variable because the share of movers is much more accurate than in the original dataset. On the other hand, these movements are also less endogenous than the movements that we observe in the original dataset. The last step will be to check which sub-groups of workers, in terms of their education, are more able to capture the education externalities, and test the learning hypothesis, namely that the wage of the workers in a more educated location will grow faster than the others.

3.2.1 Estimation procedure using the pooled cross-sectional data

The main problem with the pooled data is related with the sample dimension, which is computationally onerous. Therefore, a two step estimation procedure will be considered. This strategy requires a first stage, where a regression-adjusted mean wage in city c at time t , λ_{ct} , is obtained from the following regression (runned for each year):

$$\log w_{ijct} = \lambda_{ct} + \mathbf{X}_{it}\boldsymbol{\beta} + \mathbf{Z}_{jt}\boldsymbol{\delta} + \sum_{r=1}^5 R_{irt} + \varepsilon_{ijct}, \quad (24)$$

where $\log w_{ijct}$ is the log of the hourly wage of the individual i , who works in the firm j in county c , observed at time t . \mathbf{X}_{it} is a vector of individual characteristics (gender, (potential) experience and years of schooling), \mathbf{Z}_{jt} is a vector of the observable characteristics of the worker's firm j and R_{rt} are region-year dummy variables that have a value of one if the establishment where the worker is employed is located in region r , in year t . $\boldsymbol{\beta}$ and $\boldsymbol{\delta}$ are the vectors of associated coefficients. λ_{ct} is a set of city-time dummies that can be interpreted as a vector of adjusted city average wages.

In the second stage, we treat the resulting panel of 1650 (275 cities \times 6 years) $\hat{\lambda}_{ct}$ and estimate longitudinal regressions with the following specification:

$$\hat{\lambda}_{ct} = \gamma_{\overline{S}} \overline{S}_{ct} + \varsigma_L L_{ct} + \varsigma_V V_{ct} + \sum_{r=1}^5 \sum_{t=1}^6 R_{crt} + \phi_c + u_{ct}. \quad (25)$$

\overline{S}_{ct} is the average education level in the city c at time t . $\gamma_{\overline{S}}$ is the externality related with average education and ϕ_c is the parameter that captures the effects of time invariant unobserved city characteristics not time variant. Note that ϕ_c can not vary over, otherwise we can not identify the $\gamma_{\overline{S}}$. Therefore, and in

order to account for local demand shocks on economic activity, we also include a set of region-year fixed effects and two other time varying variables, the (log of) city employment in private sector L_{ct} and the (log of) city average sales per worker V_{ct} . Finally, u_{ct} , is the error term. As pointed by Card and Krueger (1996), this two step estimating strategy is asymptotically unbiased and efficient if proper GLS weights are used in the second stage. Therefore, estimation is by weighted least squares, where the weights used are number of observations per city to account for differences in the precision of the first stage estimates, and White-corrected standard errors are requested.

3.2.2 Estimation procedure using the displaced workers sample

Other important source of omitted variables is individual unobserved heterogeneity. In fact, if better workers may be attracted to cities with high human capital, then individual ability will be positively correlated with average education. This correlation can arise because workers are not randomly assigned to cities, but tend to choose the city where their skills are most valued. However, we would not have this problem if we based our estimation on a group of workers that were exogenously removed from their jobs and then randomly assigned to new firms. Some workers were assigned to firms in their original city, while others were assigned to firms in other cities. Therefore, individual and average city ability would not be correlated with average education and we could obtain an unbiased estimate of the externality, using a simple OLS approach.

Unfortunately, we do not have data on such experiment, but we can select a group of workers that were displaced and who lost their jobs because of establishment closings. Remark that this sample is not completely random if the

probability of being displaced by an establishment closing differ across cities and is correlated with city average education. Also, movers may have different characteristics of the stayers, and the location choice before and after displacement is not, obviously, completely exogenous, because workers tend to choose cities that have higher returns to their skills.⁷

In light of these limitations, we adopt the following approach. We regress a base mincerian wage equation in first differences, which remove individual fixed effects and other time invariant variables (such as gender or age). With city fixed effects, we can control for (time-invariant) individual and city heterogeneity:

$$\begin{aligned} \Delta \log w_{ijc} = & \gamma_{\overline{S}} \Delta \overline{S}_c + \Delta \mathbf{X}_{it} \boldsymbol{\beta} + \Delta \mathbf{Z}_j \boldsymbol{\lambda} + (\phi_{tc} - \phi_{(t-\tau)c}) + \\ & \sum_{r=1}^5 \sum_{t=1}^6 (R_{irt} - R_{ir(t-\tau)}) + \varsigma_L \Delta L_c + \varsigma_V \Delta V_c + \Delta \varepsilon. \end{aligned} \quad (26)$$

We also impose a time-variant coefficient to individual education (β_{St}), and a dummy variable equal to one if the worker changed the city of work, in order to control for any mobility premium. This regression is runned first with predisplacement and two years after displacement data, and secondly with predisplacement and five years after displacement data. These regressions are also runned separately for stayers and movers.

With this data we also intend to distinguish between the effect of local average education on the wage level or on the wage growth. In fact, it is possible that the benefits of interacting in a better educated environment do not appear immediately, but only over time. Higher local education may facilitate coor-

⁷For a similar procedure see Gibbons and Katz (1992) or Neal (1995) on the estimation of industry-specific human capital.

dination and allow individuals to specialize, making easier for workers to find the best jobs for themselves. Also, an educated labor force might speed the rate of interactions with high-skill individuals who can be imitated or the rate at which agents have new experiences (see Glaeser, 1999, for a formalization). This growth wage effect will be tested using an interaction term between tenure and average city education. If the returns to tenure after displacement increase with average education, then we can infer that, presumably, there are some productive skills that are acquired over time, and are related with the educational environment.

3.3 Data Description

The dataset used in this paper was constructed from the Quadros de Pessoal, of the Ministry of Labor and Solidarity (MTS). Beginning in 1982 and on a yearly basis, this Ministry has been collecting information on all companies operating in Portugal, except family businesses without wage-earning employees, through a mandatory questionnaire. Reported data match the firm, the establishment and each of the workers, and include the worker’s gender, age, skill, occupation, schooling, tenure and earnings as well as the firm’s location, industry employment level, sales volume and legal setting. The existence of a unique identification number (social security number) for the workers and firms enables the construction of a panel of workers (although we only use a panel of workers in the second set of regressions). Since the data includes detailed information on plant location at the city (“concelho”) level⁸, it is possible to retain variables not only to characterize workers and firms, but also to characterize their

⁸ “Concelho” is a fairly small administrative area, with an average area of 322 km². Between 1989 and 1998 the total number of “concelhos” in the continental part of Portugal was 275.

location.

From the original dataset, we selected the observations on the following basis: first we dropped part-time workers as well as workers that did not work the normal period in the month of the survey (about 22% of whole dataset). Recall that the information on social security numbers is not validated because is not used for the production of official statistics and consequently there are some coding error and missing observations. Therefore, we dropped all observations without a valid identification number (3 to 7%, depending on the year) and dropped all individuals whose identification number appear twice or more, after keeping the full-time workers. This is a suspicion of a typo or a mistake when the data was introduced, but also could be the case that some individuals have more than one full time job. Note that if some workers have a full-time job and a part-time one, than the information related with the later job is deleted, while we maintained the former.

Then, we excluded all the observations for which one of the variables used in our analysis is missing, such as education level or date of birth and then we retained only the workers in firms with more than six employees, non agriculture or fishery, and located in the continental part of Portugal. From each year we selected randomly 20% of this “cleaned” dataset, due to computing capacity. Our final dataset is summary described in Table 1. which shows the average hourly wages as well as the (weighted) average city education, before and after data selection.

[Table 1 here]

The average nominal yearly nominal wages in our final dataset are higher (roughly 4%) than the ones observed in the original dataset. This is not sur-

prising because we drop workers from typically low paid jobs, as agriculture or part-time workers. However, we only observe small increase of about 1% in the mean of average city education variable, which is a signal that the selection of observations did not change their distribution across space.

In order to reduce the endogeneity of movement decision we considered a sample of displaced workers, who lost their jobs because of firms closings in 1993 and 1994⁹. Nevertheless, displaced workers after displacement tend to earn less than the average of the original sample of workers, which can be related with the fact that displaced workers have lower education than the overall average. However while the first sub-sample (displaced workers in 1992) shows lower wages than average, the second sub-sample has higher nominal hourly wages than average. Table 2 compares some variables of both samples, in 1992 (before displacement) and 1995 (after displacement).

[Table 2 here]

Note that from the sample of displaced workers in 1992 (46,440 workers) and from the one in 1993 (103,653 workers) we only found 13,699 in the 1995 records and 19,949 in the 1996 records, respectively. Two possible explanations for this: the first one is the possibility that some workers choosed to retire after the displacement (this is consistent with the data concerning the average age of this sample); the second explanation lays in the fact that other workers could be either self-employed or unemployed in 1995 or 1996, or in other case, they found a job in public admistration.

⁹We assumed that we observe a firm closing if the identification number of one firm appeared in 1992 but did not appear in 1993, or appear in 1993 and did not in 1994. However, it is possible that some firms changed the identification number due to mergers or splits. Therefore, we dropped all workers for whom the date of admission (observed in 1995 and 1998, from the 1992 sample; and observed in 1996 and 1999, from the 1993 sample) was before 1992 or 1993 (about 1/3 of the sample).

3.4 Wage Determination and Dispersion in the Portuguese Labor Market

Portugal is one of the OECD economies with the highest degrees of wage flexibility and responsiveness of wages to the macro unemployment rate (see OECD, 1992 or Modesto and Monteiro, 1993). However, the intermediate nature of centralization in the Portuguese wage bargaining system does not allow any clear answer about wage adjustment at the micro level. In fact, some guidelines for wage increases are set at the central level by the government, unions and employers' associations. On the other hand, it is possible to bargain at the firm or sectorial level due to the scattered nature of the union structure. This means that collective bargaining is extensively applied, setting minimum wage levels for different categories of workers. Therefore, the use of information about the firms' characteristics and worker's occupation is crucial in our subject.

Nevertheless, wage drift has been increasing in the Portuguese economy, especially for highly skilled and white-collar workers. According to Cardoso (2000), wage dispersion across firms is particularly pronounced for workers with high levels of schooling and for those with high tenure, while experience is valued in a more uniform way. This fact will be particularly important if there are differences between the type of worker in terms of his ability to capture the human capital externalities: the wage response to local education externalities will be more clear for workers with more schooling.

In terms of the inequality observed at wage level, Portugal has an inequality pattern close to that of the UK, which has been increasing over the last two decades (Cardoso, 1998). This increase of inequality is related mainly to a rise in the premium to higher education and in more complex jobs, while the

premium related to tenure has been falling.

The spatial wage dispersion has been less studied than the dispersion observed at sectorial or firm level. However, some authors (see e.g. Vieira, Hartog and Pereira (1997)) argue that earnings differ significantly across regions, even when other characteristics of the firms or workers are controlled for.

From the Table 11 (in Data Appendix) we can infer that the dispersion of both a county's average hourly wage and county employment have been decreasing, in spite of their large range of variation. However, average education remains at a very low levels, comparing with other European countries' education level¹⁰, even if it increased 1.25 years during this period (see Table 8 in Data Appendix).

3.5 The Variables of Interest

The Data Appendix gives us detailed information about all the variables. The wage variable that we used was the log of hourly earnings, where earnings were defined as the summation of all regular wage components. Earnings and labor time were measured in the months of March (from 1989 to 1993) and October (from 1994 to 1999). This variable is not deflated by the consumer price index because we will use region-time dummies in all our regressions in order to eliminate both inflation and unrelated regional business cycle effects.

The information about the education of the workers was given in levels, so we converted it to the correspondent years of schooling. To compute the average schooling at the firm level and at the county level, we exclude the worker's own

¹⁰The share of the labor force with upper secondary or higher education, in 1992, was 55.8% in France and was 34,1% in Italy, while in Portugal was close to 25%. See OECD (1994).

education, in order to avoid multicollinearity problems. From the workers file we extracted the variables gender, age, occupation and tenure. From the firms file we used sector (we set 23 different sectors), legal setting, equity capital share of foreign owners and employment level. The location of the worker was computed using the location of his establishment. We also include the a dummy for each region (we consider 5 different regions) and the (log of) city’s employment in private sector, as well as the (log of) city’s sales per private employee. All the variables were computed using the same dataset.

4 The Role of Local Average Education Capital on Wages: Regressions and Results

4.1 Results based on the pooled cross-section data

The next table shows the regressions based on the pooled cross-section data, using information on all full-time workers, in the private sector of the portuguese economy. The estimated equation is (25), after regressing (24). From columns (1) to (3) we do not include firm controls, in order to compare our results with similar estimates of other works. Columns (4) to (6) include firm controls.

[Table 3 here]

Regression (0) shows that, if we compare two workers in locations in which average schooling differs by one year, the gap between their wages would be about 18.4%, on average (we are only controlling for region-year effects). When we include individual characteristics (schooling, potential labor market experi-

ence and gender), as in regression (1a) the coefficient is now 8.4%¹¹. Note that, the change from 18.4% to less than one half (8.4%) is indicative that sorting effects are very important. It is implied in this fact that if there is sorting on observables, sorting based on unobserved individual ability should also be expected. This topic will be addressed latter.

The inclusion of city fixed effects reduces the coefficient associated with average education to almost one quarter of the value found in regression (1a). This means that a very significant part of the relationship between average schooling and wages is due to omitted city characteristics. The inclusion of the two controls for local demand shocks reduces further the estimate to 1.7%, as we see in regression (3a).

When we add firm and job characteristics (regression (1b) and (3b)), the coefficient associated with average city education is reduced dramatically, first to 2.4% (without city fixed effects) and then becomes negative (although not significant) if we consider the full equation, with controls for unobserved city characteristics and local demand controls (regression (2b) and (3b)). These results show that even the small value of 1.7% found in (3a) can not be interpreted as human capital externalities through local interactions, but is, in fact, a function of the firm variables. This fact is particularly important because other studies do not take these variables directly into account, particularly the average education of the workers of the individual's firm.

Should we infer that there is no external effect of education on individual

¹¹Acemoglu *et al* report an estimate of 16.8%, for the US economy in 1990, in a regression that contains individual education, year-of-birth, and state-of-birth main effects, for a sample of white males aged 40-49. They report an estimate of 7.2% using 1950 and 1990 Census data, when controll for state-of-residence main effects. This estimate is not completely comparable with ours, because we consider all full time workers (male, female and no age restriction) and we do not include city-of-birth effects.

wages, if we use a complete set of controls? In fact some of these externalities are captured by firm controls, while long term externalities are captured by county dummies. That will be the case if the spillovers from education are not captured by individuals immediately, but along their lives. On the other hand, we are assuming that all individuals benefit in the same way from the existence of knowledge spillovers, which can be a misleading simplification. In fact, we can argue, not only that the process of acquiring knowledge is not instantaneous, but also that the ability to absorb information is not the same across different types of individuals. This is the reason why we want next to focus on the subsample of displaced workers.

4.2 Results based on the sample of displaced workers

Our objective, the estimation of the role of local human capital on the worker's wage, shares most of the identification problems that arise from the estimation of the causal effects of group interactions¹². Consider, again, our basic wage equation (8). Since we can not observe η_i , the individual specific effect, given the OLS properties we should consider the fixed effect or a first differences estimator, or alternatively, an IV estimator. With first differences estimation, as in equation (26), we get unbiased estimates for the coefficient of interest, if η_i does not vary over time. However, self-selection biases can arise also in a fixed effects model if returns to ability change across firms or locations, and these returns are correlated with average education of the city. On the other hand,

¹²See e.g. Manski (1993) about the problem of the identification of endogenous social effects. For interesting applications on inter-industry wage differentials see Krueger and Summers (1988) or Gibbons and Katz (1992). See also Ichino and Maggi (2000) and Bertrand, Luttmer and Mullainathan (2000) for applications of similar procedures.

we only can identify $\gamma_{\overline{S}}$ if the average schooling levels of the worker's city change over time. If the worker does not move between cities, we are unlikely to observe large changes in this variable. The analysis of displaced workers is needed not only because we get more variation on the city features (since firm mobility is associated with geographical mobility, in significant share of the cases)¹³, but also because mobility after displacement is more likely to be exogenous.

The results presented above, in Table 3, showed that the impact of local knowledge externalities on the workers' wage seems quite small. However, as we quoted above, we are assuming that all individuals benefit in the same way from the existence of knowledge spillovers, which can be a misleading simplification. If the ability to absorb information is not the same across different types of individuals, we should take this into account in our econometric specification. We can expect that more educated workers will benefit more from a more educated environment than less educated ones, not only in the short run, but also in the long run.

Table 4 represents the main results of a first differences estimation, adding two more features, relative to the previous estimation. First we will estimate two different equations (one with observations on workers displaced in 1993 or in 1994 and observed before displacement - 1992 or 1993 - and in three years later and the other based on the same predisplacement sample but observed six years later (in 1995 or 1996), and second we will consider the interactions between the county's average education and the individual's education level.

[Table 4 here]

Although the interpretation of the results of the regressions without inter-

¹³In our case, about 1/3 of displaced workers moved between counties in the period 1992-1995, while the overall mobility rate is roughly 8% (consider all dataset) in the same period.

actions follows the same rules as for a conventional fixed effects estimation, the equation with interactions should be interpreted more carefully. While there is no significative difference between the coefficient associated with local average education by different schooling levels in the equation with three years lag, we found different gains after 5 years of displacement, where higher educated workers benefit more from a better-educated environment. An increase of one year on local average education, raises high school and college graduate wages by 3% more than the wage of an individual's with basic schooling. Note that we are considering a time-variant coefficient to individual education (β_{st}), and dummy variable equal to one if the worker changed the city of work, in order to include some control for mobility premium.

For the moment we cannot conclude that more educated individuals are the ones that benefit from an interaction externality, if individuals tend to choose locations where their ability is better remunerated. This means that the returns to ability may be location specific, and are correlated with local education. In order to check whether there the positive result for the better educated workers is due to an externality or due to sorting, we run the same type of regressions as before, but now separately for movers and stayers. If the results do not differ significantly, we have to conclude that the externality may play some role on the setting of the wage of better educated individuals. Table 5 shows the main results.

[Table 5 here]

We found two interesting results: first there is no positive or significant coefficient on local average education for the equation with three years of lag, either for stayers or movers. This is the first sign that mobility can be considered

as exogenous, after the proper controls are used. Second, we confirm the result showed in table 4: better-educated workers benefit more from a better educated environment, only after a certain period of time, whether they are stayers or movers.

So far we have some evidence that time combined with the educational level of the city as some role on the acquisition of skills. This growth wage effect will be tested again, using an interaction term between tenure and average city education. Tenure (in the post-displacement job) can be used as proxy for the time that individual is exposed to some environmental conditions. If the returns to tenure increase with average education, then we can infer that, presumably, there are some productive skills that are acquired over time, and are related with the educational environment.

[Table 6 here]

These results are interesting in the sense that returns to tenure are sensitive to the worker’s environment, and to the worker’s type. As before, better educated individuals benefit more from an increase in local education through time (as tenure increases). For example, an increase of one year in the local average education combined with five years tenure, provides a premium of 3.4% ($2.9\% + 5 \times 0.001\% = 3.4\%$), as the same increase observed in an individual with basic education and the same tenure after displacement.

5 Conclusion

In this paper we try to better understand the positive association between average local education and individual wages. Our dataset allows to control for

the observable characteristics of the firm, namely to control for the effect of the general level of education within the firm on the individual's productivity. as well as to control for time invariant individual characteristics.

Our empirical results, controlling for individual fixed effects, indicate that an increase of one year in the average duration of schooling in Portuguese counties has a small positive external effect on individuals' wages of 1.7%. However this result flops to zero if we add a set of firm controls. Therefore, pre-determined characteristics of the worker's location, and the spatial sorting of the firms can explain almost all the association between average city education and individual wages, holding the worker's schooling constant. Also, this result is consistent with the more recent empirical works on this subject.

However, it seems that the ability to capture this externality differs depending on the type of worker. Using a sample of displaced workers, after 5 years of being displaced, the wages of a college graduate increase by more than 3.0%, relative to a worker with basic education if both observe a change in the average education of their county by one year. This result is interesting because it is robust to the imperfect substitution hypothesis. Under this, an estimate of the externality related with local education on the wages of better-educated workers must be understood as a lower bound of the true value, due to decreasing returns to education. On the other hand, considering explicitly the mobility decision does not change significantly the result. Also, adding an interaction term between tenure and average education, provides more evidence that education externalities may act mainly through learning.

Therefore we can not conclude that externalities from education do not exist. In fact, there may be important externalities from schooling not reflected in

higher wage rates for other. For example, many authors argue that education has a social benefit from reducing crime rates or making citizens better voters. On the other hand, if education externalities appear through the firm channel, it would be important to explore the role of human capital in the localization decision of the firm. As more educated workers are attracted to locations where their skills are better paid, as more high-tech industries would choose such locations in order to benefit from a pool of high skilled human capital. This can be true, namely for industries where information is a key factor. Another possible path to explore are the channels through which knowledge is transmitted, namely the inter-industry versus intra-industry channels, and look at the effects of intra-industry and inter-industry externalities on employment and wages growth.

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A Tables

Table 1: Information extracted from the original dataset in 1989, 1991, 1993, 1995, 1997 and 1999

Year	Original Dataset			Final dataset		
	Nr. of obser.	Nom. hourly wages	Av. City Education	Nr. of obser.	Nom. hourly wages	Av. City Education
1989	2.169.835	335.8	5.86	234.032	345,9	5.95
1991	2.233.237	485.1	6.19	247.800	506.6	6.25
1993	2.215.481	612.5	6.46	250.178	634.0	6.56
1995	2.232.548	698.4	6.75	267.020	730.4	6.82
1997	2.350.782	772.0	7.07	283.277	799.5	7.15
1999	2.568.456	885.4	7.43	293.391	917.3	7.51

The hourly wage was defined as the summation of all regular wage components divided by the normal labor time.

Earnings and labor time were measured in the month of March (in 1989, 1991 and 1993) and October (1995, 1997 and 1999).

Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

Table 2: Comparison of both samples of workers

Year	Number of Obs.			Av. Nom. Hourly Wages			Av. Worker Education		
Variable	(1a)	(2a)	(3a)	(1b)	(2b)	(3b)	(1c)	(2c)	(3c)
1992	2,268,151	46,440	-	563.6 (1.050)	422.4 (355.1)	-	6.35 (3.61)	5.66 (2.90)	-
1993	2,215,481	-	103,653	611.3 (861.6)	-	707.1 (591.7)	6.55 (2.47)	-	6.73 (3.78)
1995	2,232,548	13,699	-	696.3 (998.0)	552.0 (477.8)	-	6.80 (2.49)	6.35 (3.08)	-
1996	2,233,721	-	19,940	737.5 (1,053.2)	-	631.5 (631.2)	6.95 (2.51)	-	6.66 (3.32)
1998	2,430,691	16,104	-	845.0 (1,234.4)	711.5 (657.4))	-	7.32 (2.65)	6.61 (3.22)	-
1999	2,568,456	-	24,784	885.3 (1,260.4)	-	777.4 (680.3)	7.50 (2.80)	-	6.74 (3.33)

Columns (1a), (1b) and (1c) refer to the original sample - all records.

Columns (2a), (2b) and (2c) refer to the displaced workers in 1993 sub-sample.

Columns (3a), (3b) and (3c) refer to the displaced workers in 1994 sub-sample.

Source: "Quadros de Pessoal" Dataset

Table 3: Base Wage Regressions (Weighted Least Squares - all sample 1989-1991-1993-1995-1997-1999)

Dep.Var: Log of Hourly Wage	Regressions without Firm Controls			
	Simple Level Effect	Base Wage Eq.	w/ City Fixed Effects	w/ Local Demand Controls
	(0)	(1a)	(2a)	(3a)
Av. County Education (\bar{S}_{ct})	0.184*** (0.004)	0.084*** (0.002)	0.022*** (0.006)	0.017*** (0.005)
Individual Characteristics (X_{it})	-	Yes	Yes	Yes
City Fixed Effects (ϕ_c)	-	-	Yes	Yes
Local Demand Controls L_c & V_c	-	-	-	Yes
R-Squared	0.9652	0.876	0.969	0.971
Regressions with Firm Controls				
		(1b)	(2b)	(3c)
Av. County Education (\bar{S}_{ct})		0.028*** (0.002)	-0.005 (0.006)	-0.009* (0.005)
Individual Characteristics (X_{it})		Yes	Yes	Yes
City Fixed Effects (ϕ_c)		-	Yes	Yes
Local Demand Controls L_c & V_c		-	-	Yes
R-Squared		0.810	0.950	0.954
N. Obs.1650 (275 cities \times 6 years)				

The dependent variable in column (0) is the average of the individual log wage.
In columns (1)-(3) the dependent variable is a regression-adjusted mean wage in city c at time t , λ_{ct} .
This adjusted mean is obtained regressing the log of hourly earnings on some individual characteristics.
These are: gender, potential experience and years of schooling (in levels).
The dependent variable in columns (4)-(6) is a regression-adjusted mean obtained as in columns (1)-(3)
but adding some firm and job quality variables. These variables are tenure, occupation,
sector (23 different sectors), legal setting, equity capital share of foreign owners and employment level.
We consider also five different regions, and we include in all regressions region-year dummies.
Robust standard errors, adjusted for individual serial correlation, are reported in parenthesis
with * representing a significance level lower than 10%, ** a significance level lower than 5%
and *** a significance level lower than 1%.
Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

Table 4 - First Differences: Displaced Workers (1992 & 1993-1995 & 1996 and 1992 & 1993 - 1998 & 1999)

Dep.Var: Dif.(Log of Hourly Wage) $t - (t - \tau), \tau = 3, 6$	(1995 & 1996)-(1992 & 1993)		(1998 & 1999)-(1992 & 1993)	
	Wage Eq. without	Wage Eq. w/	Wage Eq. without	Wage Eq. w/
	Firm Controls	Firm Controls	Firm Controls	Firm Controls
Dif.(Av. County Education)	-0.013 (0.017)	-0.034** (0.016)	0.010 (0.013)	0.006 (0.012)
Dif.(Av. Firm Education)	-	0.012*** (0.001)	-	0.016*** (0.001)
Interaction w/ Education				
Dif.(Av. County Ed.)	-0.016 (0.017)	-0.034** (0.016)	0.000 (0.013)	0.001 (0.012)
Dif.(Av. County Ed.)X High School & College	0.015* (0.009)	-0.003 (0.008)	0.049*** (0.008)	0.030*** (0.007)
N. Obs.	49,198 Observations on 24,599 indiv.		60,164 Observations on 30,082 individ.	

The log of hourly earnings was defined as the summation of all regular wage components.
Earnings and labor time were measured in the month of March (in 1989 to 1993) and October (1994 to 1999).
We use the following set of controls: individual characteristics (years of schooling (in levels)) job quality (tenure and occupation), firm characteristics (sector legal setting, equity capital share of foreign owners, employment level, year - region dummies, and county dummies).
A dummy for city movers is included, and we allow to individual returns to education to change over time.
Standard errors are reported in parenthesis with * representing a significance level lower than 10,
** a significance level lower than 5 % and *** a significance level lower than 1%.
The expression Dif.(var) refers to difference of the variable var observed in the extremes of the period.
Education level of until 12 years schooling was the comparison group.
College refers to workers with more than 12 years schooling.
Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

Table 5 - First Differences: Displaced Workers (1992 & 1993-1995 & 1996
and 1992 & 1993 - 1998 & 1999) - Movers vs Stayers

Dep.Var: Dif.(Log of Hourly Wage)	(1995 & 1996)-(1992 & 1993)		(1998 & 1999)-(1992 & 1993)	
$t - (t - \tau), \tau = 3, 6$	Wage Eq. only for		Wage Eq. only for	
	Stayers	Movers	Stayers.	Movers
Dif.(Av. County Education)	-0.014	-0.037	-0.011	0.040*
	(0.018)	(0.034)	(0.014)	(0.024)
Dif.(Av. Firm Education)	0.011***	0.014***	0.015	0.017***
	(0.002)	(0.002)	(0.002)	(0.002)
Interaction w/ Education				
Dif.(Av. County Ed.)	-0.014	-0.036	-0.020	0.031
	(.019)	(0.034)	(0.015)	(0.024)
Dif.(Av. County Ed.)X High School & College	0.001	-0.004	0.060*	0.028***
	(0.046)	(0.010)	(0.035)	(0.009)
N. Obs.	15,367 ind. $\times 2$	9,232 ind. $\times 2$	18,188 ind. $\times 2$	11,894 ind. $\times 2$

All the controls are defined as before.

Standard errors are reported in parenthesis with * representing a significance level lower than 10%,

** a significance level lower than 5% and *** a significance level lower than 1%.

The expression Dif.(var) refers to difference of the variable var observed in the extremes of the period.

Education level of until 12 years schooling was the comparison group.

College refers to workers with more than 12 years schooling.

Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

Table 6 - First Differences: Displaced Workers (1992 & 1993-1995 & 1996 and 1992 & 1993 - 1998 & 1999) - Interaction with tenure and Education Level

Dep.Var: Dif.(Log of Hourly Wage)	(1995 & 1996)-(1992 & 1993)	(1998 & 1999)-(1992 & 1993)
Interaction w/ Education and Tenure		
Dif.(Av.CityEd.)	-0.036** (0.016)	-0.008 (0.012)
Dif.(Av.CityEd.) \times (HS & Coll.)	-0.005 (0.008)	0.029*** (0.007)
Dif.(Av.CityEd.) \times Tenure	0.0009* (0.0005)	0.001*** (0.0002)
Dif.(Av.CityEd.) \times Tenure \times (HS & Coll.)	0.003*** (0.0009)	0.001** (0.0004)
N. Obs.	49,198 Obs. on 24,599 indiv.	60,164 Obs. on 30,082 indiv.

All controls are the same as in the table before.
Standard errors are reported in parenthesis with * representing a significance level lower than 10%,
** a significance level lower than 5% and *** a significance level lower than 1%.
The expression Dif.(*var*) refers to difference of the variable *var* observed in the extremes of the period.
Education level of until 12 years schooling was the comparison group.
College refers to workers with more than 12 years schooling.
Source: Portuguese Ministry of Labor and Solidarity, "Quadros de Pessoal" Dataset.

B Data Appendix

The empirical work presented in this paper is based on the dataset “Quadros de Pessoal”, of the Ministry of Labor and Solidarity (MTS). Beginning in 1982 and on a yearly basis, this Ministry has been collecting information on all companies operating in Portugal, except family businesses without wage-earning employees, through a mandatory questionnaire. This dataset covers, roughly, one half of all the active population. Table A1 reports the number of records for the years under consideration.

Table 7: Number of records in 1989, 1991, 1993, 1995, 1997 and 1999

Year	Workers	Firms	Establishments
1989	2 169 835	137 155	161 094
1991	2 233 237	148 602	173 551
1993	2 215 481	184 306	193 804
1995	2 232 548	192 270	223 393
1997	2 350 782	213 589	248 664
1999	2 568 456	244 241	284 368

The access to this dataset is conditional on the rules presented in the agreement between the University of Minho and the Department of Statistics of the MTS, and is possible under request.

The dataset is made up of three files:

(i) the workers’ file, with data from 1985 to 1989 and from 1991 to 1998. This includes the worker’s identification number (social security number), gender, age, skill, occupation, schooling, tenure, date of the last promotion, profession, earnings and number of working hours. These information is relative to the month of March (from 1989 to 1993) or October (from 1994 to now).

(ii) the firms’ file, with data since 1985. The main variables present in this file are: the firm’s identification number, location (at county level), the establishment and firm’s identification number, sector, legal setting, type of agreement between firm and unions, equity capital, share of national owners in the equity capital, share of foreign owners in the equity capital, share of public owner in the equity capital, yearly sales, number of establishments (since 1994), employment level (observed in March, between 1985 and 1993, and observed in the last week of October, since 1994) and date of the constitution (since 1995).

(iii) the establishments’ file, with the firm’s identification number and that of the one of the establishment (generated inside each firm), location, sector and number of employees.

B.1 Variables extracted and / or generated from the dataset

From the dataset, and after merging the three files, we extracted the following variables:

(i) Information about workers (subscript i denotes worker i):

- Log of the hourly wages: $\log \text{hour}_i = \log \frac{\text{regular monthly earnings before taxes}}{\text{regular working hours}}_i$.

- Potential experience:

$$\text{Potexp}_i = \begin{cases} (\text{age} - \text{years of education} - 5.75), & \text{if years of education} \geq 9 \\ (\text{age} - 14) & \text{if years of education} < 9 \end{cases}.$$

- Gender: variable $male_i = \begin{cases} 1 & \text{if male} \\ 0 & \text{if not} \end{cases}$.
- Education, dummies for 8 classes of different education levels and the respective correspondence with years of schooling:

Education Level of i	Competence	Correspondence with years of education
Educ_0	No reading or writing	0
Educ_2	Basic reading or writing	2
Educ_4	Primary school complete	4
Educ_6	Intermediate school	6
Educ_9	Lower high school	9
Educ_12	High school	12
Educ_15	College degree (3 years)	15
Educ_17	College degree (5 years)	17

- Tenure: $tenure_i = (\text{date of the questionnaire} - \text{date of admission})$, converted to years.

- Generated the dummy variable $new_i = \begin{cases} 1 & \text{if } tenure < 1 \\ 0 & \text{otherwise} \end{cases}$.
- Occupation : 8 different levels (converted to dummies):

Occupation Level of i	Description
Quali_1	Executive and managerial
Quali_2	Intermediate managerial and executive
Quali_3	Low managerial
Quali_4	Technicians highly specialized
Quali_5	Sales, administrative and precision production
Quali_6	Administrative support, and production
Quali_7	Unskilled
Quali_8	Apprentice

(ii) Information about firms:

- Individual's i firm's average education i : $edfirm_i = \frac{(\sum_j^J educ_j)}{J-1}$, and $j \neq i$, where J is total level of employment in the i 's firm.

- Firm's legal setting:

Var.	Legal setting
$Legal_1$	firm owned by the state
$Legal_2$	private firm - individual owner
$Legal_3$	private firm - collective owner
$Legal_4$	cooperative
$Legal_5$	non profit organization

- Sector (one dummy for each sector):

Sector	Description	Sector	Description
1	Agriculture and fishery (dropped)	13	Water, electricity and gas
2	Mining	14	Construction
3	Food, beverages and tobacco	15	Services concerning vehicles
4	Textiles	16	Wholesale
5	Leather	17	Retail
6	Wood products and cork (without furniture)	18	Hotels and restaurants
7	Paper and printing	19	Transportation services and communications
8	Petroleum refining, rubber, plastics and chemicals	20	Banking and insurance services
9	Other non-metallic mineral products	21	Other business and professional services
10	Iron and steel	22	Real estate
11	Metal products and machinery	23	Other services
12	Furniture and other manufacturing		

- Level of employment: $npessm$: employment level (observed in March, between 1985 and 1993, and observed in the last week of October, since 1994).
- $pkestr$ share of foreign equity capital.

(iii) Information about localization:

- Average education of the i 's city = $edcity_i = \frac{(\sum_c^C educ_c)}{C-1}$, where C is total level of employment in the i 's city. We do not take into account workers with double identification numbers or with no information about schooling level.

- Log of the City employment: $\log Emp_i = \log(\text{employment observed in city of the worker } i, \text{ in the private sector})$.

- Log of the City Sales per capitaemployment:

$$\log Sales_i = \log \left[\frac{(\text{summation of the sales of all firms located in the } i\text{'s city})}{(\text{employment observed in the city of the worker } i, \text{ in the private sector})} \right].$$

- Region of the establishment (dummy variables):

$regio_1$ if the estab. is located in the Region "Norte"

$regio_2$ if the estab. is located in the Region "Centro"

$regio_3$ if the estab. is located in Lisbon or neighborhood districts (Setubal or Santarem)

$regio_4$ if the estab. is located in the Region "Alentejo"

$regio_5$ if the estab. is located in the Region "Algarve"

B.2 Observations extracted from the original dataset

From the original dataset, we selected the observations on the following basis. First we dropped part-time workers as well as workers that did not work the normal period in the month of the survey (about 22% of whole sample). Recall that the information on social security numbers is not validated because is not used for the production of official statistics and consequently there are some coding error and missing observations. Therefore, we dropped all observations without a valid identification number (from 7% in 1989, to 3% in 1999) and dropped individuals whose identification number appear twice or more, after keeping the full-time workers. This is a suspicion of a typo or a mistake when the data was introduced, but also could be the case that some individuals have more than one full time job. Note that if some workers have a full-time job and a part-time one, than the information related with the later job is deleted, while we maintain the former.

Then we retained only the workers in firms with more than six employees, non agriculture or fishery, and located in the continental part of Portugal. Table A2 summarizes the average hourly wages as well as the (weighted) average county education.

Table 8: Information extracted from the original dataset from 1989 to 1999

Year	Original Dataset			Final dataset		
	Nr. of obser.	Nom. hourly wages	Av. City Education	Nr. of obser.	Nom. hourly wages	Av. City Education
1989	2.169.835	335.8	5.86	234.032	345.9	5.95
1991	2.233.237	485.1	6.19	247.800	506.6	6.25
1993	2.215.481	612.5	6.46	250.178	634.0	6.56
1995	2.232.548	698.4	6.75	267.020	730.4	6.82
1997	2.350.782	772.0	7.07	283.277	799.5	7.15
1999	2.568.456	885.4	7.43	293.391	917.3	7.51

For the sample of displaced workers, we merge two sub-samples: one sample with individuals that lost their jobs because of firm closings in 1993 and the other with individuals that lost their jobs because of firm closings in 1994. We assumed that we observe a firm closing if the identification number of one firm appeared in 1992 but did not appear in 1993, for the first sub-sample, and if the identification number of one firm appeared in 1993 but did not appear in 1994, for the first sub-sample. However it is possible that some firms changed the id. number due to mergers or splits. Therefore, we dropped all workers for whom the date of admission (observed in 1995 and 1998 or observed in 1996 and 1999) was before March 1992 or March 1993 (about 1/3 of the sample). Table A3 summarizes the information available from this sample.

Table 9: Information about displaced workers from firm closures (displacement in 1993)

Year	Nr. of obser.	Hourly wages	Av. Worker Education	Av. Worker Age
		(nominal)	(Years of schooling)	(Years)
1992	46,440	422.4	5.66	36.3
1995	13,699	552.0	6.35	35.0
1998	16,104	711.5	6.61	37.0

Table 10: Information about displaced workers from firm closures (displacement in 1994)

Year	Nr. of obser.	Hourly wages (nominal)	Av. Worker Education (Years of schooling)	Av. Worker Age (Years)
1993	103,653	707.1	6.73	38.7
1996	19,940	631.5	6.66	36.0
1999	24,784	777.4	6.74	38.0

B.3 Descriptive statistics

The following tables describe this panel in more detail.

Table 11: Cities' Average Education and Hourly Wage (not weighted)

N = 275	(1) City Average Education			(2) County Av. Hourly Wage		
	Mean	<i>Stand. Dev.</i> <i>Mean</i>	Range	Mean	<i>Stand. Dev.</i> <i>Mean</i>	Range
1989	5.44	0.17	3.69 - 9.00	291.5	0.13	191 - 750
1991	5.61	0.24	3.33 - 8.07	422.2	0.12	274 - 1,116
1993	5.89	0.21	4.24 - 9.00	511.4	0.12	339 - 1,035
1995	6.21	0.21	3.70 - 8.80	596.8	0.11	386 - 1,251
1997	6.50	0.19	4.81 - 9.22	657.3	0.11	452 - 1,232
1999	6.75	0.18	5.16 - 9.74	730.9	0.10	535 - 1,436

Note: Hourly wage was computed from monthly earnings in March, from 1989 to 1993 and October from 1994 to 1999. Unit: Portuguese Escudos.

Source: Portuguese Ministry of Labor and Solidarity ("Quadros de Pessoal").